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ABSTRACT

Two studies were performed to evaluate the extent to which response patterns and sustained attentiveness is a function of the demands of a secondary task, primary task difficulty, and feedback arrangements. The first study varied primary task stimulus difficulty level, feedback arrangements on the primary task, and presence of the secondary task. The main objective of the second study was to determine whether primary task feedback arrangements would interact with secondary task demands to influence attentiveness to the primary task; thus, primary task difficulty was held constant, and primary task feedback arrangements and secondary task difficulty level were varied. Results showed that subjects were able to detect changes in stimuli used in the primary task and to detect presentations of the secondary stimuli, although apparently subjects were not consistently attending to stimulus characteristics. Further, there seemed to be some dimunition in attention to stimulus characteristics and a greater reliance on feedback whenever feedback was available on the primary task. Overall, results suggest the need for multilevel model of attention and that it is not sufficient to conceive of stimulus control in a unitary sense. (SH)

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Sustained Attention and Response Rate as a Function of Task Difficulty and Feedback Arrangements[1]

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One of the frequent admonitions in programmed instruction and behavior modification is that appropriate behavior should immediately be reinforced on a continuous reinforcement schedule. Within the laboratory context, the principle has widely been accepted. Thus, it was with some considerable surprise that practitioners have found not only that immediate, continuous reinforcement has not produced the expected results, but that such reinforcement arrangements may even have deleterious effects (Anderson, 1971; Glaser, 1966).

The present research was designed to explore the notion that the problem may lie in the subjects' failure to attend to pertinent aspects of the learning situation, and that optimal feedback arrangements to facilitate such attentiveness will depend in part on the difficulty of the task involved. It is assumed that the usual objective in a practical learning situation is to have the subject learn what stimulus attributes can serve as cues to appropriate behavior, and that feedback arrangements primarily are of value in assisting the subject to detect which stimuli lead to appropriate behavior and which lead to inappropriate behavior.

Skinner (1953) characterized attentiveness as involving varying degrees of antecedent stimulus control. More recently several authors

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(e.g., Annett, 1969; D'Amato, 1970; Hendry, 1970; Kintsch, 1970) have suggested that the main role of reinforcement in attention and learning may primarily be informational rather than motivational. Thus one can conjecture that subjects will attend to certain aspects of the learning situation (i.e., these stimuli gain control) because of the information which is provided concerning appropriateness of cue stimuli in guiding behavior. Although some (e.g., Ray and Sidman, 1970) have utilized a modified discrete-trial paradigm to study reinforcement principles in stimulus control, the present investigators have preferred using a modified free operant paradigm because it affords a more detailed analysis of changes in subjects' behavior.

There was some suggestion in a previous study (Snelbecker & Schwaab, 1968) that intermittent schedules of reinforcement may lead to greater attentiveness than does reinforcement of every correct response. Results from animal studies have been somewhat contradictory (Annett, 1969; Ferster, 1960; Nevin, Cumming & Berryman, 1963; Nevin, 1967); the problem is relatively unexplored concerning human attentiveness in absolute judgment tasks (Annett, 1969; Swets & Kristofferson, 1970). Discrete trial absolute judgment performance appears to be conjointly influenced by feedback arrangements and task difficulty (Snelbecker & Fullard, 1971). Attentiveness to visual and auditory stimuli has frequently been observed to diminish within relatively short periods of time (Snelbecker, 1967; Swets & Kristofferson, 1970). Under modified free operant conditions involving two operants, response rates are directly related to intermittency in the reinforcement schedule, and response rate for easy problems has been consistently higher

than for difficult problems (Snelbecker & Schwaab, 1968).

There were two major purposes in the present studies: (1) to evaluate the extent to which response patterns and sustained attentiveness is a function of the demands of a secondary task, primary task difficulty, and feedback arrangements; and (2) to refine a behavioral measure of attentiveness, especially for that aspect of selective attention which is characterized as stimulus control.

General Method

In both experiments reported in this paper, 12 adult subjects (different naive subjects for each experiment) were paid a flat monetary rate for participation in addition to an approximately equal amount of money which they earned for correct responses to the experimental tasks. Subjects sat in front of a Lehigh Valley Electronics two rail human test console with an add-subtract counter mounted in the center top row and 16 keys mounted across the bottom row. Pure tone stimuli, generated by a Wavetek 136 Programmable Oscillator, were presented to the subjects via TDH-39 earphones. Tonal stimuli were selected from the 100-8000 Hz range, with sound pressure level adjusted so that tones appeared equally loud. Data were recorded simultaneously and automatically on a series of digital counters and an Esterline-Angus 20-channel event recorder.

In both experiments there was a primary task and a secondary task. The primary task consisted of identifying a pure tone with one of the keys in the console (an absolute identification task) and pressing that key repeatedly to gain points on an add-subtract counter (a modified free operant procedure). Prior to each experiment subjects were given

a series of practice trials so that each subject had learned the association of tones and their respective keys to a sufficient degree. In Experiment 1 they had three presentations of the tonal series in random order. In Experiment 2 they were given the tones in random order until they reached a criterion of 70% correct on a block of 10 tones. They also were given practice on each feedback arrangement. During the actual experimental segments, subjects could accrue points (subsequently worth money) on the primary task by pushing the correct key while a tone was playing. The secondary task was a discrete trial task which consisted of interspersed short tones (½-second duration) at preprogrammed times, which the subject was required to identify as "low" or "high;" in the first experiment this required a rather simple identification, whereas the secondary task in the second experiment required short term retention and comparisons of paired tones. Correct responses on the secondary task accrued points which were worth money, but the subject was not informed of the accumulating amounts until the end of a trial block.

Experiment I

Method

In the first experiment there were three independent variables of interest:

1) stimulus difficulty level of the primary task - 4 tones vs. 10 tones in a set;
2) feedback arrangements on the primary task - fixed ratio 5 (every fifth correct response reinforced) vs. fixed ratio 30 (every thirtieth correct response reinforced);

3) presence vs. absence of a secondary task. The dependent variables of interest were: a) total number of key presses on primary task; b) proportion of correct key presses; c) response rate during last five seconds of primary task; d) number of "overflow" responses (number of presses a subject made on a previously correct key after a new primary task stimulus was presented; e) number of correct identifications on the secondary task.

Procedure

Subjects responded under eight experimental conditions resulting from combinations of the two levels of primary task difficulty, two types of feedback arrangements, and the presence or absence of the secondary task. Each segment consisted of a random order of the primary task tones for 7½ minutes. Each tone played for an average of 45 seconds, with durations ranging from 35 to 55 seconds, during which the subject was to gain points by repeatedly pressing the correct console key. Under those conditions with a secondary task, subjects made an absolute identification of one of two tones ("low" tone, 100 Hz; "high" tone, 6200 Hz). The subject identified a low tone by one response on a special pushbutton, and identified a high tone by two responses on the same push button. Secondary tones, presented for ½ second, were randomly interspersed during the primary tones; 10 secondary tones were presented in each experimental segment. Each subject had all 8 experimental segments in a partially randomized sequence. Half of the subjects received the four FR 5 segments first, and half of the subjects received the four FR 30 segments first. The other experimental conditions occurred randomly.

Results

For each of the dependent variables, a 2x2x2 analysis of variance (Primary Task Difficulty x Feedback Arrangement x Secondary Task Condition) with repeated measures on all factors was conducted for each of the dependent variables (Kirk, 1968). The results of these analyses were:

1) Total number of key presses on primary task. There were no significant main effects nor interactions.

2) Proportion of correct key presses. There were significant main effects for Primary Task Difficulty ($F = 61.20$, df 1/11, $p < .001$), Feedback Arrangement ($F = 78.37$, df 1/11, $p < .001$), and Secondary Task Condition ($F = 6.69$, df 1/11, $p < .05$). A significant interaction of Feedback Arrangement x Primary Task Difficulty was also found ($F = 12.03$, df 1/11, $p < .01$). In order to evaluate the simple main effects of this interaction, a series of Tukey tests of comparisons between means were conducted (Kirk, 1968). These tests indicated: the means for 4 and 10 tones were nonsignificantly different at FR 5 but significantly different at FR 30 ($p < .01$); the means at FR 5 and FR 30 were significantly different at 4 tones ($p < .05$) but more so at 10 tones ($p < .01$). Table 1 presents the mean proportion of correct key presses corresponding to the above effects.

3) Response rate during last five seconds of primary task. There were no significant main effects nor interactions.

4) Overflow responses. There was a significant main effect for Primary Task Difficulty ($F = 8.32$, df 1/11, $p < .01$). The corresponding mean overflow responses were: Four-tones = 3.21; 10 tones = 3.54.

5) Number of correct identifications on secondary task. There were no significant main effects nor interactions. There was practically no variance, with subjects having near perfect scores under all conditions.

Additionally, as an explication of the nature of the overflow response variable, Spearman rank-order correlation coefficients were computed for the following: overflow responses and response rate in last five seconds of primary task (4-tone conditions, $\rho = .29$, nonsignificant; 10-tone conditions, $\rho = .30$, nonsignificant); overflow responses and total responses on primary task (4-tone conditions, $\rho = .08$, nonsignificant; 10-tone conditions, $\rho = .14$, nonsignificant). Given the nonsignificant correlations between the overflow response variable and the two measures of response rate, it was concluded that overflow was more than a simple reaction time index.

Experiment II

The comparatively small number of overflow responses during the first experiment indicated that subjects could maintain at least some degree of attentiveness to auditory stimuli to a greater extent than had been anticipated from previous research. Experiment I also showed that attentiveness on the primary task (i.e., overflow responses) was adversely influenced by the difficulty level of the primary task (i.e., better attentiveness with the 4-tone set than with the 10-tone set). Moreover, expected results were obtained in that feedback arrangements and primary task difficulty interacted in influencing proportion of correct responses on the primary task.

The main objective in the second experiment was to determine whether primary task feedback arrangements would interact with secondary task

demands to influence attentiveness to the primary task. Drawing from contemporary short term memory research, it was theorized that "attentiveness" involves repeated sampling of stimuli and storage so that comparisons can be made as to whether the same or a different tone was being presented. Thus it would be expected that attentiveness to the primary task would be adversely influenced by competing secondary tasks, and that the difficulty level of the secondary task would determine the extent of this interference with attentiveness to the primary task.

Method

Procedure

Using experimental segments comparable in length to those employed in Experiment I, the second experiment held constant primary task difficulty (only 5 tones were used) and manipulated primary task feedback arrangements (FR 5 vs. No feedback until end of the experimental segment) and secondary task difficulty level. Each experimental segment (7½ minutes duration) consisted of 5-second presentations of primary tones--during which the subject repeatedly pressed the appropriate key to accrue points separated by intervening 5-second silence periods. During some of these silent periods one of the secondary tone pairs was presented; following another 5-second presentation of a primary tone, the second of the pair was presented. The subject's secondary task was to determine whether the second tone was lower than, equal to, or higher than the first tone presented. As in the first experiment, these responses were made on a special pushbutton. These secondary tone pairs either differed by 20 Hz (high secondary task difficulty) or by 175 Hz (low secondary task difficulty). Subjects made 10 of these comparisons during each of the 4

experimental segments.

As in the first experiment, each subject had all experimental conditions. Subjects were randomly assigned to one of two random sequences of the experimental conditions. Dependent variables of interest were: 1) total number of key presses on the primary task; 2) proportion of correct primary key presses; 3) number of correct identifications on the secondary task.

Results

A 2x2 analysis of variance (Feedback Arrangement x Secondary Task Difficulty) with repeated measures on both factors (Kirk, 1968) was conducted for each of the three dependent variables. These analyses showed:

1) Total number of key presses on primary task. There was a significant main effect for Feedback Arrangement ($F = 12.32$, df 1/11, $p < .01$), and there was a significant interaction of Feedback Arrangement x Secondary Task Difficulty ($F = 6.08$, df 1/11, $p < .05$). In order to evaluate the simple main effects of this interaction, Tukey tests of comparisons between means were conducted (Kirk, 1968). These tests revealed that there was a nonsignificant difference between the two feedback conditions under the high task difficulty condition but that significantly more presses were made under the FR 5 condition than the no feedback condition at the low task difficulty condition ($p < .01$). Examined another way, Tukey tests showed that response rate was higher for low secondary task difficulty than for high secondary task difficulty under the FR 5 condition ($p = < .05$) but that there was no diffierence under the No Feedback condition.

General Discussion

Contrary to most previously reported studies (Swets & Kristofferson, 1970) all 12 subjects in the first experiment were quick to detect both the change in the primary stimuli and the presentations of the secondary stimuli. However, both subjective reports and general patterns of the responses when new stimuli were presented indicated that subjects were not consistently paying attention to characteristics of the stimuli. The distinct impression one gains from these data is that subjects maintained sufficient attentiveness to detect change in the stimuli but that they did not consistently attend to the stimulus so as to know which stimulus was being presented. For example, they made rather gross errors in trying to identify the correct key for a new stimulus even though they rapidly detected that some new stimulus had been presented.

Response rate seemed more robust than suggested by usual single operant studies, so that response rate was not greatly affected by feedback arrangements and other experimental conditions. Of course, this may be due primarily to the small difference between an FR 5 and an FR 30 schedule, but pilot data and previous studies (Snelbecker, 1967; Snelbecker & Schwaab, 1968) with one or two response keys had resulted in greater influences by schedules than was apparent in the present study. There is some suggestion of need for more research on schedule effects for concurrent operant arrangements, especially when many different responses are involved.

Again in the second experiment, subjects were very quick to detect that there was a change in the stimulus being presented. However, here too the response patterns and subjects' remarks during post-experiment inter-

views revealed that they had not consistently paid attention as to which stimulus was being presented. In both studies there even seemed to be some dimunition in attention to stimulus characteristics, and a greater reliance on feedback, whenever feedback was available on the primary task. This was more readily discernible in the Easterline - Angus records, but it is partly illustrated by the data in Table 2. Obviously, without feedback, subjects had fewer correct responses. Without feedback there was a minimal level of response rate and a minimal accuracy level (above chance levels) which subjects maintained. With feedback they maintained about an 80% accuracy level but increased response rate under the low secondary task difficulty condition--i.e., the condition which provided less competition from the secondary task. The differential conjoint effects of task difficulty and feedback arrangements on total key presses as compared to accuracy level supports the notion that there are different levels of attentiveness and that there may be different controlling factors. Finally, the differences in secondary tasks between these two experiments and their differential effects merit consideration. It appears that some secondary tasks pose a divided attention dilemma for the subject. This was exemplified in Experiment II where relatively low levels of attention to the primary task resulted from the stringent demands of the secondary task (i.e., around 61% accuracy level), while quite comparable primary tasks in the first experiment had resulted in a much higher performance level (i.e., around 90% accuracy level).

Overall these results suggest need for a multilevel model of attention and thus suggest that it is not sufficient to talk about stimulus control in a unitary sense.

Footnote

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Table 1

Proportion of Correct Key Presses on the Primary Task by Levels of Feedback Arrangement, Task Difficulty, and Presence/Absence of Secondary Task

Feedback Arrangement	
FR 5	FR 30
91.94	86.85

Task Difficulty	
4 Tones	10 Tones
90.65	78.15

Secondary Task	
Present	Absent
82.96	85.83

	Task Difficulty	
	4 Tones	10 Tones
Feedback Arrangement		
FR 5	95.67	88.21
FR 30	85.63	68.08

Table 2

Mean Number of Key Presses and Proportion Correct on the Primary Task as a Function of Feedback Arrangement by Secondary Task Difficulty

	Secondary Task Difficulty					
	High		Low			
Feedback Arrangement	Presses	Prop. Correct	Presses	Prop. Correct	$\bar{X}$	
Feedback (FR 5)	1523.75	.80	1771.75	.77	1647.75	.79
No Feedback	1379.58	.42	1332.50	.45	1356.04	.44
$\bar{X}$	1451.67	.61	1552.13	.61		

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Abstract

Two experiments focused on optimal conditions for presenting information in education and rehabilitation. Sustained attention (persistent responding on previously correct keys showed extent of attentiveness), response rate and response patterns were studies as a function of feedback arrangements and task difficulty. In both experiments reported in this paper, 12 adult subjects participated in a two-hour experimental session for which they were paid a flat monetary rate in addition to money earned for correct responses. Results are discussed with reference to theoretical models of attention and to extrapolation of experimental single operant research findings to complex practical situations.